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RESTRICTED

From: Chief, Naval Technical Mission to Japan.
To : Chief of Naval Operations.

Subject: Target Report - Japanese Anti-Radar Coverings.

Reference: (a) "Intelligence Targets Japan" (DNI) of 4 Sept. 1945.

1. Subject report, covering Target E-06 of Fascicle E-1 of reference (a), is submitted herewith.

2. The report was prepared by Lieut. R.C. Brooks, USNR, with the assistance of Lieut. Eric W. Jordon, RNVR.

C. G. Grimes

C. G. GRIMES
Captain, USN

RESTRICTED E-06

ELECTRONICS TARGETS
JAPANESE ANTI-RADAR COVERINGS

"INTELLIGENCE TARGETS JAPAN" (DNI) OF 4 SEPT. 1945
FASCICLE E-1, TARGET E-06

DECEMBER 1945

U.S. NAVAL TECHNICAL MISSION TO JAPAN

SUMMARY

ELECTRONICS TARGETS

JAPANESE ANTI-RADAR COVERINGS

Japanese research in the field of anti-radar coverings was quite intense, and while several research products proved to be rather successful, according to the data presented, it was difficult to use in practice. Such information as was available is included in this report, and was obtained from the Air Technical Intelligence Group, which initiated the request for interrogations, data and samples. Reference is made to ATIG Reports #153 and #114, the latter prepared for ATIG by Dr. Wilkenson, a civilian engineer associated with that group.

The two major contributions are an anti-radar paint, the work of Major K. MANO of the Tama Technical Institute, a Japanese Army research organization, and Dr. SHIBA of the Tokyo Engineering College, and absorbing materials, in rubber, for micro-waves. This last research was conducted at the direction of the 2nd Naval Technical Institute and engineered by the Nippon Broadcasting Corporation and the Sumitomo Electric Co.

Abstracts of the reports are given for their interest value. The basic reports of ATIG should be studied for complete details.

TABLE OF CONTENTS

REFERENCES

A. Location of Target:

1. Second Naval Technical Institute, Tokyo Branch, MEGURO.

2. Tokyo Engineering College.

B. Japanese Personnel Interviewed:

1. Capt. Y. YAJIMA, Administrative Assistant to Admiral NAWA, 2nd Naval Technical Institute.

2. Dr. K. MORITA, Tokyo Engineering College, an authority on theoretical micro-wave techniques and magnetron design.

C. Reports of Other Allied Agencies:

1. ATIG #153, report on Anti-Radar Paint.

2. ATIG #114, Dr. Wilkenson's report on Japanese electronics.

INTRODUCTION

Research carried out in the United States indicated some success in the development of anti-radar coverings. The extent to which the Japanese had progressed along these lines was not known and consequently became one of many targets for investigation.

Preliminary questioning at the 2nd Naval Technical Institute and at the Tokyo Engineering College revealed that ATIG personnel had already made initial contacts on this subject, and that information was being collected for them.

No further investigations were carried out, and reference is made to ATIG reports, abstracts of which constitute the body of this report.

THE REPORT

PART I - ANTI-RADAR PAINT

During June 1943, Major K. MANO of the Tama Technical Institute, and Dr. SHIBA of the Tokyo Engineering College began experiments to develop an anti-radar paint. These researches produced several types of paint, or covering, that gave acceptable results. Among those offering most promise were:

Paint Mixture	Results
Ferric oxide and liquid rubber	Very good
Ferric oxide, asphalt and airplane dope	Very good
Ferric oxide and paint	Fairly good
Hammer scale, asphalt and paint	Good
Butanol and alcohol	Very poor

The information given above is incomplete and no detailed reports are available. However, other members of the Mission have collected samples of the paint, and reference will be made to them at the end of this report.

Laboratory tests were conducted by coating an aluminum sheet with varying thicknesses of the mixtures and measuring the reflection coefficient. While no information is available on how these measurements were made, it was found that a two millimeter thickness was best for frequencies centering around 1500 megacycles, and a one millimeter thickness for 3000 to 4500 megacycles. These tests refer to the ferric oxide, asphalt and dope mixture.

No attempt was made to field test the mixtures on aircraft because of the known, or assumed, effect on performance. The paint was heavy, difficulty to apply, and would have increased the drag considerably. In 1944, a small harbor patrol craft was coated with the most promising mixture, and tests were run with rather poor success using TASE 2, a 15.7 centimeter army radar. The Navy did not consider the use of these paints a practical solution to the problem. Exposure to salt water soon caused the mixture to peel off, not to mention the effect of temperature on the coating. Lack of mechanical strength, excessive weight, poor adhesive qualities, and rapid deterioration were the major factors against its use.

Dr. MASAKI of the Electro-Chemical Laboratory, Communications Ministry, is reported to have tried a paint with ferric oxide and magnesium oxide in suspension. Laboratory tests are reported to indicate 90% absorptions of 1500 to 3000 megacycle radar signals; however, no details of measurement are specified.

These investigations were conducted at the request of the Japanese Army, and the Navy placed little faith in their methods. ATIG Report #153, available to this Mission only in abstract, should give more complete details.

PART II - ABSORBING MATERIAL FOR ELECTRO-MAGNETIC WAVES

The Japanese Navy placed greater credence in the use of absorbing material than in paints, and under the direction of the Second Naval Technical Institute, research problems were allocated to the Japanese Broadcasting Corporation and to the Sumitomo Electric Co., Ltd. The Sumitomo report is being returned to Washington for study by the Naval Research Laboratory, Anacostia, D.C., and the Electronics Division of the Bureau of Ships.

The abstract that follows is taken from the report by I. MURAKAMI, "On the Absorbing Materials of Electro-magnetic Waves".

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"There are two methods by which reflections of radar signals from surfaces might be considerably reduced. One, by the selection of suitable surface contours in order to minimize reflection in the direction of the radar receiver. Two, by the use of absorbing layers of suitable characteristics applied to the surface exposed to the radar waves. It is understood, of course, that a combination of these two principles would produce the best results.

"Basically, it is necessary that the absorbing layer have the smallest coefficient of reflection at the frequency of the radar wave. Therefore, initial research was on the method of measuring reflection coefficients at the very high frequencies of 3000 megacycles, and was followed by development of suitable absorbing materials, both experimentally and from theoretical data.

"The absorbing materials, in order to be practical for use on ships of all types, should fall within the following limiting conditions:

1. Raw materials used in manufacture should be plentiful.
2. Material should be adaptable to mass production.
3. Layers should be easy to apply to ship surfaces.
4. Materials should be mechanically strong and free from "chemical effects".
5. Materials should be thin and light in weight.
6. Materials should be resistant to sea water and easily sealed.
7. Materials should serve equally well as absorbing layer for super sonics.

"Considering the above conditions, research was first conducted using rubber or plastic material in which there were minute particles of conducting materials, such as carbon powder. Because the thickness of the layer was a factor in the results obtained, it was felt that by using several layers of absorbing materials with progressively varying electrical conductivity and dielectric constants, growing more dense as the radar wave penetrates each successive layer, a more effective product would result.

"Further theoretical consideration indicated the desirability of suitably corrugating the surface of the metal to which the absorbing material is applied. It was reasoned that radar waves penetrating these layers would reflect from a metal surface when incidence angles were chosen to produce maximum dispersion to the inner surface of the absorbing layers and would be totally absorbed. It was also reasoned that by selecting each individual layer for optimum effectiveness over a narrow portion of the spectrum, a material having broad-band characteristics would be produced. Broad-band operation in addition to the dispersion phenomena would be highly desirable. The foregoing phenomena could occur through the use of finely divided iron particles in the various layers, or iron powders whose permeability varies according to the frequency of the electro-magnetic waves. This method, from a theoretical standpoint, gave the most promise.

"Research and development centered about the methods employing thin layers of rubber or plastic in which there were finely divided carbon powders. The table below gives the composition of the various types of materials produced.

COMPOSITION AND CHARACTERISTICS OF SAMPLES TESTED

		Se 201	Se 202	Se 203	Se 204	Se 206	Se 208
By Weight	Raw Rubber	100	100	100	100	100	100
	Acetylene Carbon	80	40	30	20	0	0
	Gas Carbon	0	0	0	0	40	20
	Sulphur	3	3	3	3	3	3
	Zinc Oxide	5	5	5	5	5	5
	Stearic Acid	3	1	1	1	1	1
	Anteji-A (anti-oxidizer)	1	1	1	1	1	1
	D.M. (accelerator)	1	1	1	1	1	1
	Pinetor (plasticizer)	10	0	0	0	0	0
	Total	203	151	141	131	151	131
Specific Gravity		1.25	1.19	1.16	1.08	1.21	1.11
Carbon Content (% wt.)		39.4	26.5	21.3	15.3	26.5	15.3
Electrical Conductivity (in volts/meter)	D.C.	2.26	.422	.203	4.46 x 10^{-4}	small	small
Dielectric Constant	f = 3000 mc/s	4.00	2.74	2.26	0.93	small	small
	f = 3000 mc/s	42.0	25.2	19.0	5.9	7.2	4.7

"Two other samples were produced, neither available, called Se 101 and Se 104. Se 101 had an electrical conductivity (v/m) given as "small" for D.C. and 2.16 at 3000 mc/s, with a dielectric constant at 3000 mc/s of 8.6. All that is known of Se 104 is its D.C. conductivity (v/m) of 0.047.

"Practical experiments were conducted using, in one case, a built-up product of metal, 7 mm thickness of Se 101, and a 6 mm thickness of Se 104. In the second experiment, the layers were metal, Se 201 (6 mm thick), Se 202 (2 mm thick), Se 205 (2 mm thick) and Se 206 (4.5 mm thick). In the first experiment, at 3000 mc/s a reflection coefficient of 15% was obtained, and 40% on the second experiment. The first showed sharper interference phenomena; however, the second would be more practical to use. (N.B. Data on Se 205 is not available.)

"The research planned in connection with the use of finely divided iron powders was not completed because of the end of the war."

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Concurrently with the latter portion of the experiments of the Japanese Broadcasting Corporation, the Sumitomo Electric Co. laboratories were given the problem of developing an effective anti-radar covering. These experiments ran through May 1945, at which time air raids had so interrupted the work that they were moving the laboratory to a "less popular" location.

Theoretical considerations and experimental results are to be found in a report entitled "On the Absorbing Materials of Ultra Super Short Wave", a copy of which was obtained from Captain Y. YAJIMA of the Second Naval Technical Institute, Tokyo Branch, MEGURO. It was compiled from personal notes of the engineers involved, but Captain YAJIMA was unable to find out specifically who they were. Apparently all note books and data of this nature were ordered destroyed on 15 August 1945, and no one would admit that his work was reproduced in this treatise.

This document is being returned to the United States in its original form and will be available for study from the cognizant section of the Naval Research Laboratory, Anacostia, D.C.

In brief, the experiments reported concerned the use of magnetic and non-magnetic particles in the rubber base. Fair results were obtained on frequencies near 3000 megacycles, but by January 1945, as an absorber with magnetic powder did not show good result on 3cm wave length U. S. radar, study of conductive rubber containing carbon was again undertaken, especially as concerned multi-layers. The results were mildly encouraging.

Samples of the material produced in both laboratories have been submitted to NRL, as follows:

> Samples of Anti-Radar Paint on Steel Plate - NavTechJap Equipment No. JE22-2008.
> Anti-Radar Paint - NavTechJap Document No. ND22-0040.

It is understood that Dr. Wilkenson's report (ATIG #114) and samples of material collected by him will be available at Wright Field, Dayton, Ohio.